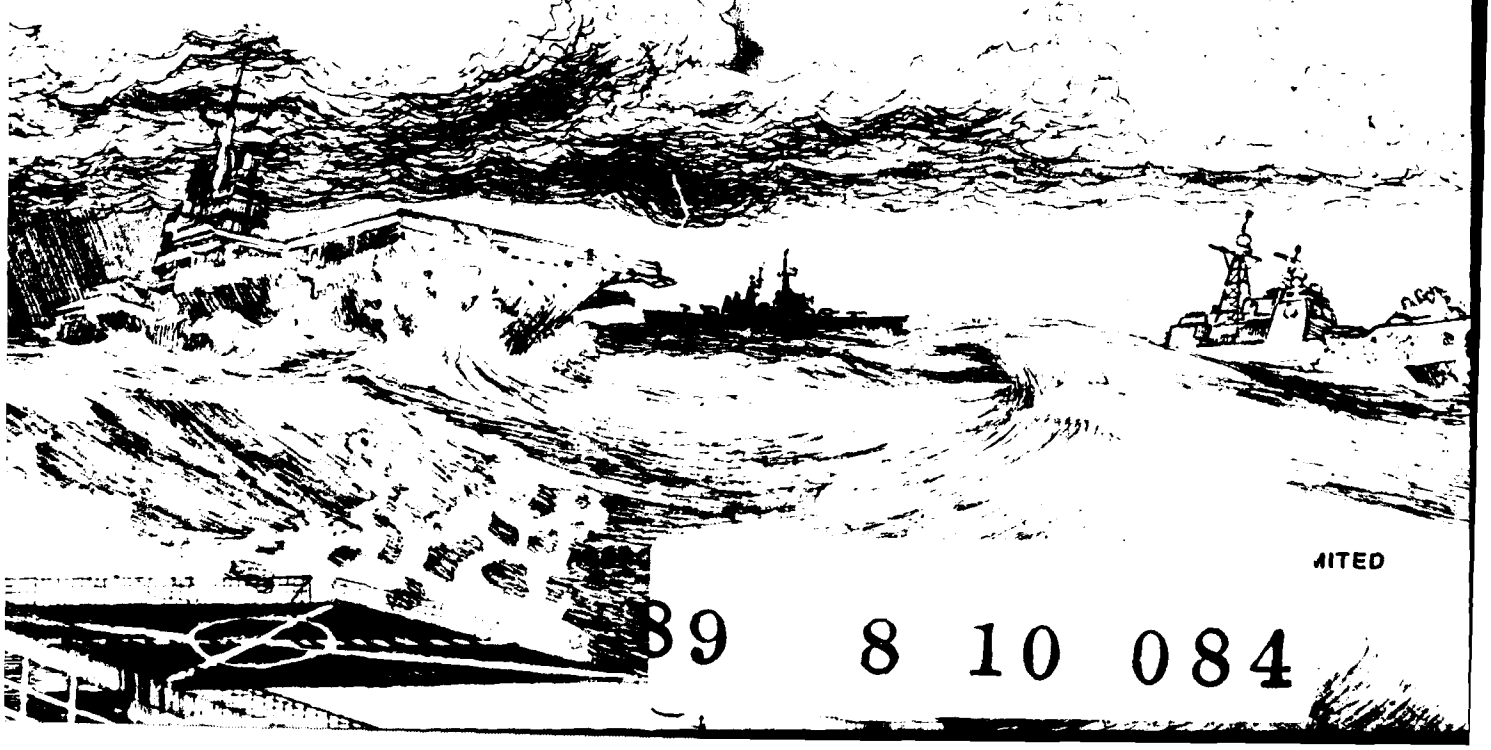
(1)

SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

30. MESSINA



REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S): CR 89-09
6a. NAME OF PERFORMING ORGANIZATION: Science Applications International Corporation; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION: Naval Environmental Prediction Research Facility
6c. ADDRESS (City, State, and ZIP Code): Monterey, CA 93940	7b. ADDRESS (City, State, and ZIP Code): Monterey, CA 93943-5006
8a. NAME OF FUNDING, SPONSORING ORGANIZATION: Commander, Naval Oceanography Command; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: N00014-88-D-0510
8c. ADDRESS (City, State, and ZIP Code): J.C. Stennis Space Center, MS 39529-5000	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Severe Weather Guide - Mediterranean Ports - 30. Messina (U)

12. PERSONAL AUTHOR(S): Englebretson, Ronald E. and Gilmore, Richard D.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 9/15/88 TO 4/15/89	1989, June	42

16. SUPPLEMENTARY NOTATION: Funding source: O&M,N-1

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP
04	02	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Storm haven; Mediterranean meteorology; Messina port; Mediterranean oceanography

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This handbook for the port of Messina, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: Dennis C. Perryman, contract monitor	22b. TELEPHONE (Include Area Code): (408) 647-4709; 22c. OFFICE SYMBOL: O&M,N-1

CONTENTS

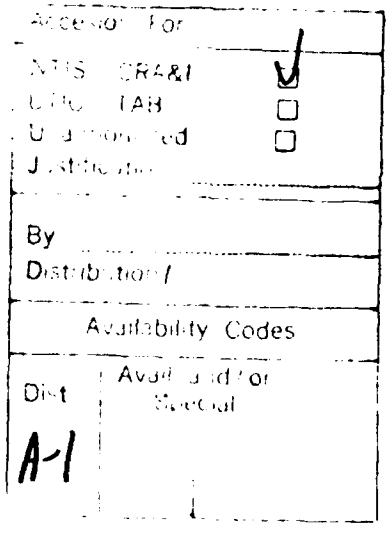
FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Naval Environmental Prediction Research Facility to create products for direct application to Fleet operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to the Naval Environmental Prediction Research Facility for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

W. L. SHUTT
Commander, U.S. Navy



PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review.

1988 NO.	PORT
1	GAETA, ITALY
2	NAPLES, ITALY
3	CATANIA, ITALY
4	AUGUSTA BAY, ITALY
5	CAGLIARI, ITALY
6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONACO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
16	BARCELONA, SPAIN
17	PALMA, SPAIN
18	IBIZA, SPAIN
19	POLLENSA BAY, SPAIN
20	LIVORNO, ITALY
21	LA SPEZIA, ITALY
22	VENICE, ITALY
23	TRIESTE, ITALY
24	CARTAGENA, SPAIN
25	VALENCIA, SPAIN

1989	PORT
26	SAN REMO, ITALY
27	GENOA, ITALY
28	PORTO TORRES, ITALY
29	PALERMO, ITALY
30	MESSINA, ITALY
31	TAORMINA, ITALY
	BENIDORM, SPAIN

1990	PORT
	TARANTO, ITALY
	ALEXANDRIA, EGYPT
	PORT SAID, EGYPT
	ANTALYA, TURKEY
	ISKENDERUN, TURKEY
	IZMIR, TURKEY
	GOLCUK, TURKEY
	ISTANBUL, TURKEY

1991	PORT
	ROTA, SPAIN
	TANGIER, MOROCCO
	ALGIERS, ALGERIA
	TUNIS, TUNISIA
	BIZERTE, TUNISIA
	SFAX, TUNISIA
	VALETTA, MALTA

1992	PORT
	SOUDA BAY, CRETE
	PIRAEUS, GREECE
	KALAMATA, GREECE
	THESSALONIKI, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	LARNACA, CYPRUS
	DUBROVNIK, YUGOSLAVIA
	SPLIT, YUGOSLAVIA
	GULF OF SOLLUM

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.
B. Cruise reports were reviewed.
C. Navy personnel with current or previous area experience were interviewed.
D. A preliminary report was developed which included questions on various local conditions in specific harbors.
E. Port/harbor visits were made by NEPRF personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.
F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,
B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,
C. local wind wave conditions, and
D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2 CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested precautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of Messina is located on the east coast of the Italian island of Sicily at approximately 38°12'N 15°34'E (Figure 2-1).

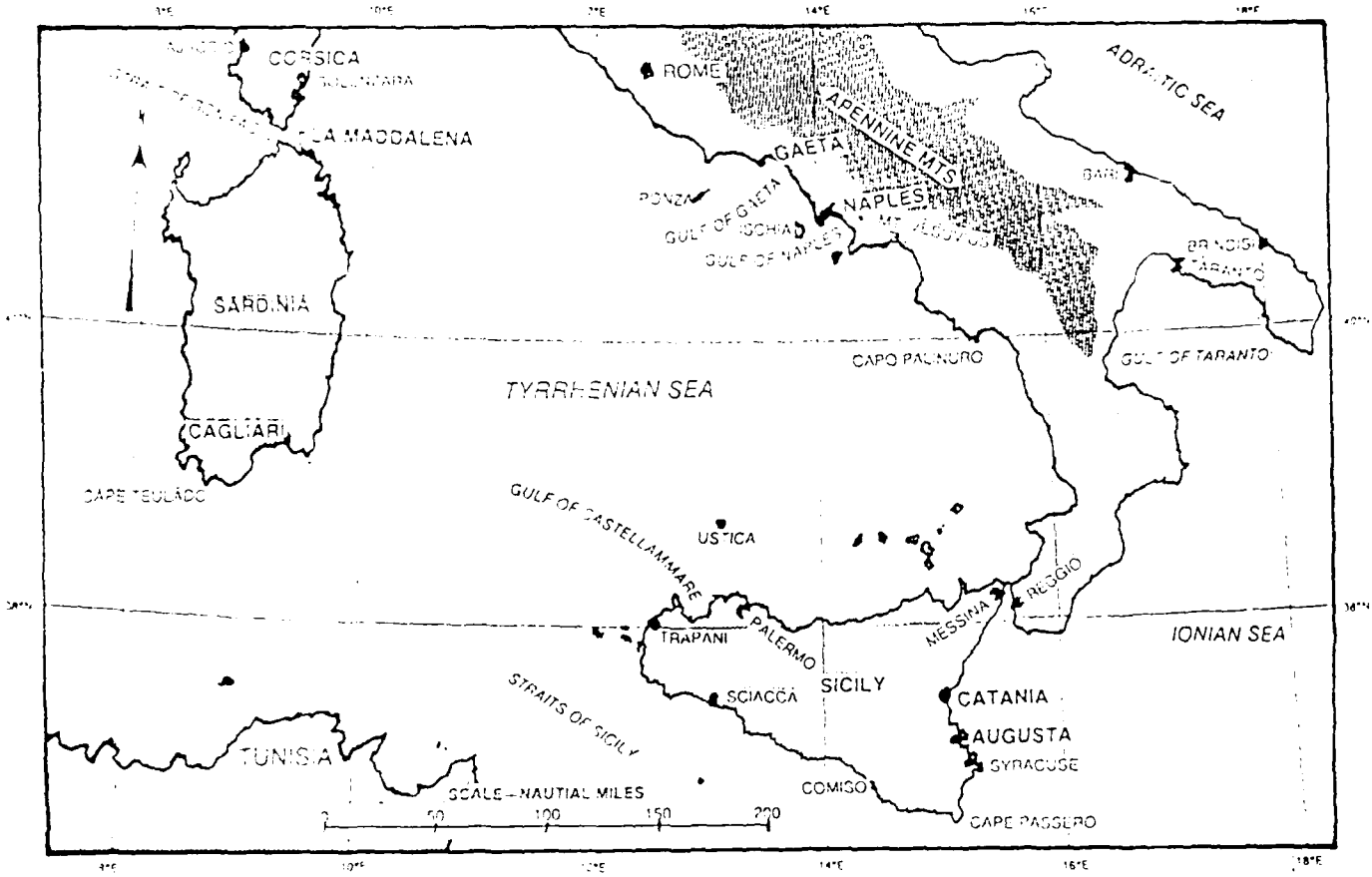


Figure 2-1. Central Mediterranean Sea.

The Port is located about 6 n mi southwest of the extreme northeastern tip of Sicily on the Strait of Messina, a narrow passage which separates Sicily from the Italian Peninsula. See Figure 2-2. The terrain west and north of the Port is rugged, with elevations commonly exceeding 1,300 ft (396 m) within 2 miles of the coast. Mt. Etna, a 10,902 ft (3,323 m) active volcano, lies about 38 n mi southwest of the Port.

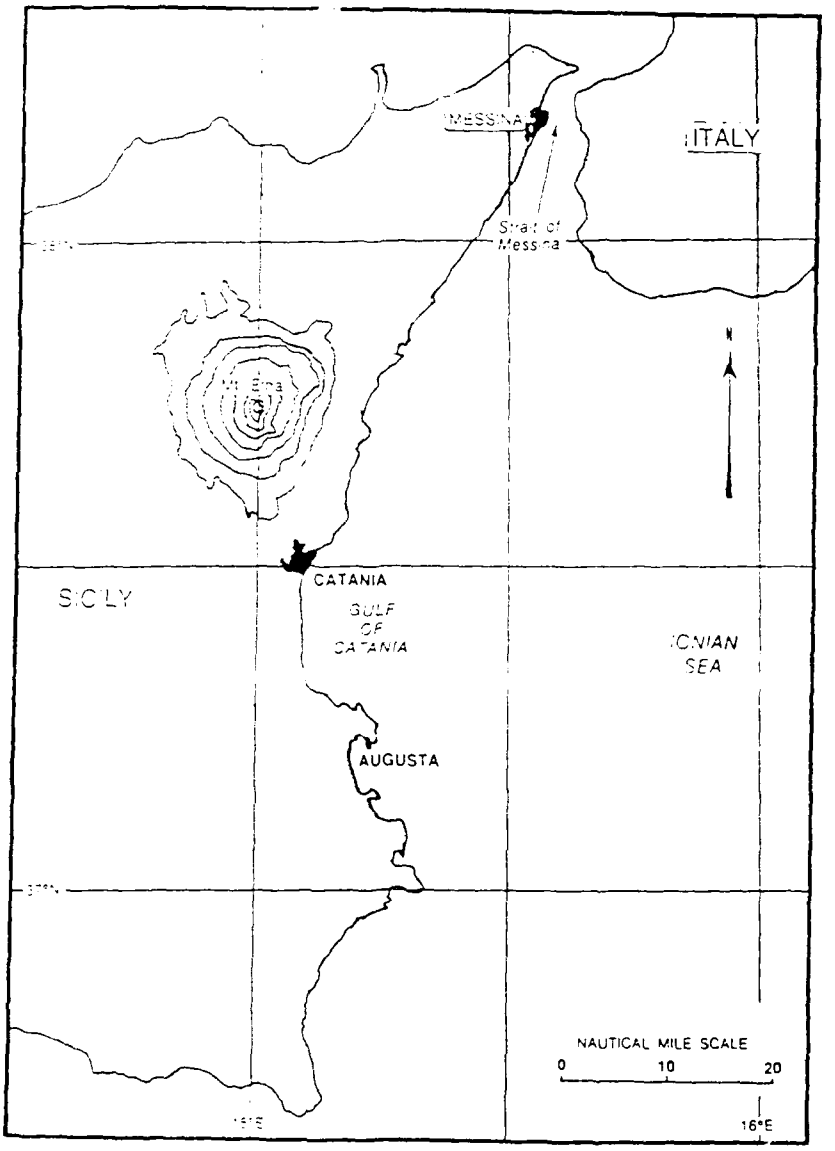


Figure 2-2. Eastern Sicily.

The Port of Messina is entered through a 1,350 ft (412 m) wide opening between Punta San Salvatore on the east and the east coast of Sicily on the west. The harbor is formed by an encircling peninsula, Braccio di San Raineri, which extends eastward from the main island, then turns northward and westward before terminating in Punta San Salvatore (Figure 2-3).

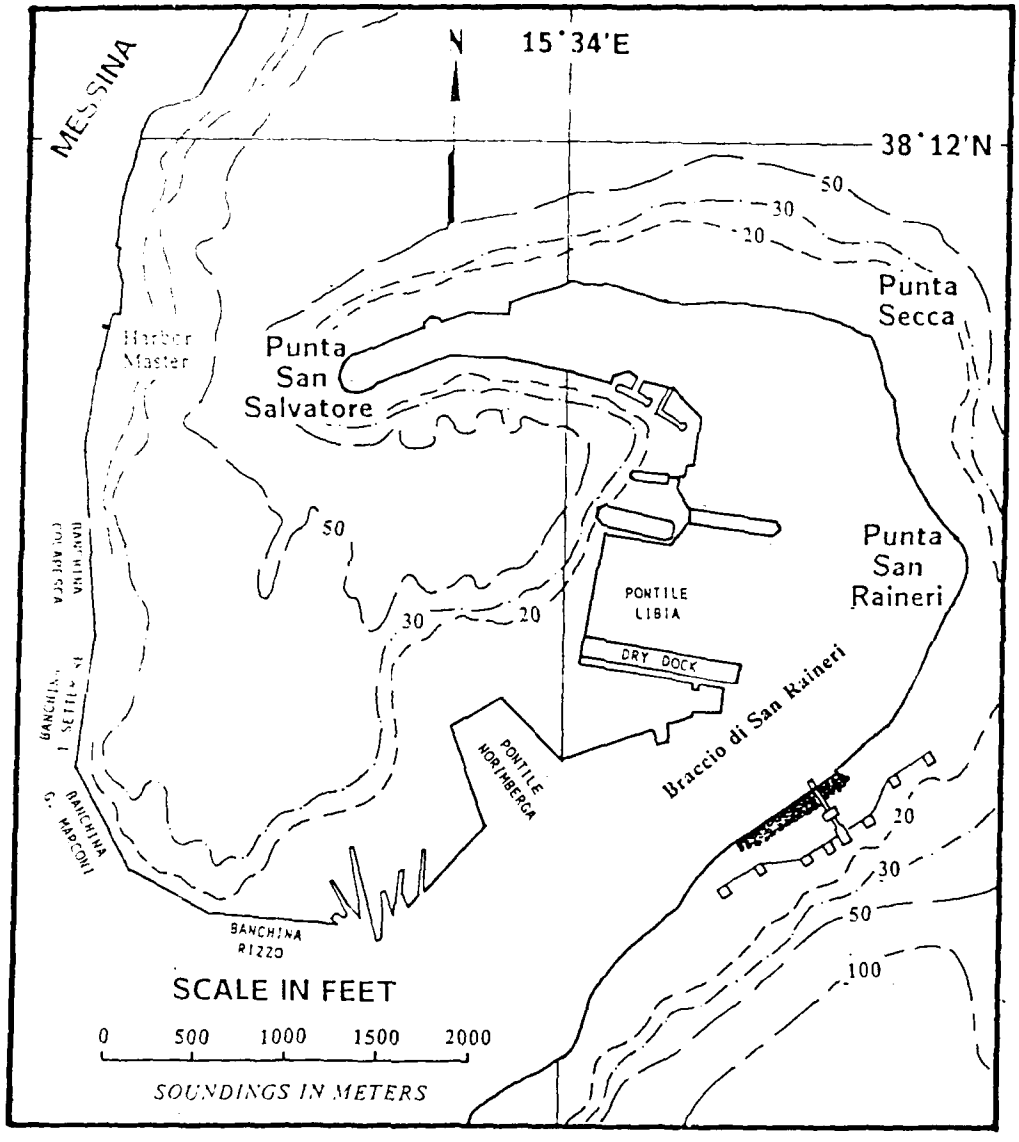


Figure 2-3. Port of Messina.

The harbor is not large, but is capable of accommodating vessels up to 820 ft (250 m) long with drafts to 29 ft (8.8 m). There is ample room for 2 LST's and an LPD at the downtown quaywall (FICEURLANT, 1986). Most berths used by U. S. Navy ships are at Banchina Colapesca and Banchina 1 Settembre, but berths at the dry docks on the harbor's east side are also used. Depths at quayside are in the 25 to 30 ft (7.6 to 9.1 m) range. In general, docking facilities are excellent for destroyer-type ships (FICEURLANT, 1986).

Anchorage is at Paradiso Roads, approximately 1.5 n mi north of the harbor entrance (Figure 2-3). Paradiso Roads offers good holding in 100 ft (30 m) depths with a sand and rock bottom. Because of strong, changeable currents at the anchorage, a 1/2 n mi swing radius is used. Ships may anchor in Messina harbor, but must be secured bow and stern to prevent swinging. Because of the abundant berthing space U. S. Navy ships normally anchor only for a short time or not at all. Anchorage in the immediate vicinity outside the harbor is not recommended as the current is strong and the holding ground is poor.

Small boat operations are usually not authorized by the Port Captain because berths are normally available immediately or within a short period after arrival. When boating is authorized, an officer's landing is established at the Harbor Master's office, and the fleet landing is established at Banchina 1 Settembre.

A strong current exists along the coast near Messina, and it normally changes direction between north and south about every 6 hours. A strong northerly wind can reduce the duration of the north-setting current to 3 hours, and increase the south-setting current duration

to 9.5 hours (Hydrographic Department, 1963). The south-setting current is the strongest of the two, with a speed of 3 to 4 kt commonly occurring. The maximum speed is 5 kt. The north-setting current has a speed of 2 to 3 kt. According to local authorities, current speeds and the direction shift are more pronounced during full moon periods, and during summer more than winter. In the Strait adjacent to Punta Secca and Punta San Raineri, the current in the central part of the strait converges with a current which is deflected from the coast, causing swirling currents which local mariners avoid as a matter of habit. Other eddies are formed along the strait between counter-currents which are close to the shore, and the main current. They are locally called "Bastardi" or "Refoli" and extend about 1/2 n mi offshore. They begin 1 to 2 hours after the current changes directions (Hydrographic Department, 1963). Tides at Messina are minimal, with a range of only 1.5 ft (.5 m) (FICEURLANT, 1986).

Specific hazardous conditions, vessel situations, and suggested precautionary/evasive action scenarios are summarized in Table 2-1.

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Table 2-1. Summary of hazardous environmental condi

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATI SITUATION AFFE
1. Strong SE winds/waves - Known as Scirocco. * Most likely to occur during October to mid-May period. * Typical strong event has wind to 45 kt, with 10 ft (3 m) waves. * Rare, stronger event may reach 70 kt, with waves to 20 ft (6 m) when wind coincides with south-setting current through Strait of Messina. * Brings hot, muggy weather in spring and summer, warm weather in winter.	Advance warning * Usually preceded by low clouds over the mainland to the SE about 12-24 hr prior to onset. * Cumuliform clouds forming and staying over Mt. Etna during SE flow. * It is usually calm, with cloudless skies overhead, the day before a Scirocco occurs. Duration * Normally lasts about 3 days. Changes in wind * Dense belts of altocumulus castellanus approaching from SW are at times associated with radical and sudden changes in both wind direction and speed.	(1) Moored or Anchored Inner harbor. (2) Anchored - Paradiso (3) Arriving/departing. (4) Small boats. Usual authorized.
2. Strong NW wind - Known as Mistral. * Most common in late winter/early spring. * Wind speed may reach 45 kt. * Offshore component prevents hazardous wave generation in harbor and anchorage at Paradiso Roads.	Advance warning * Possible anytime a strong Mistral outbreak is observed to be spreading SE across the W Mediterranean Sea.	(1) Moored or Anchored Inner harbor. (2) Anchored - Paradiso (3) Arriving/departing. (4) Small boats. Usual authorized.
3. Ash fall from Mt. Etna - Caused by eruption or emission of an ash plume from Mt. Etna.	Advance warning * May occur anytime Mt. Etna erupts or emits an ash plume and prevailing winds are from SW.	All locations/situation

1 OF 2

ronmental conditions for the Port of Messina, Sicily, Italy.

VESSEL LOCATION/ SITUATION AFFECTED		EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
(1) Moored or Anchored - Inner harbor.	(a)	The inner harbor affords good protection from waves, but offers little protection from wind. * Moored vessels should double lines. * Anchored ships, which must always be secured bow and stern to prevent swinging, will be safe except if strong winds occur. * If strong winds are forecast, anchored ships should immediately move to a berth at a quay, or weigh anchor and leave the harbor for waters which offer more protection. Moving N through Strait of Messina to lee of high terrain along the N coast of Sicily should be considered.
(2) Anchored - Paradiso Roads	(a)	THE ANCHORAGE OFFERS NO PROTECTION FROM SE WINDS/WAVES. * Vessels should weigh anchor and move to waters which are more protected. * Consider moving N to waters in lee of high terrain along the N coast of Sicily.
(3) Arriving/departing.	(a)	The inner harbor affords good protection from SE waves, but the anchorage at Paradiso Roads offers none. * The harbor can be entered during any wind condition. * Inbound vessels should ensure that berths are available at one of the quays in the inner harbor before committing to enter the Port. * Once alongside, mooring lines should be doubled. * Scirocco conditions may result in extremely anomalous radar and radio propagation due to the strong surface inversion over the water, especially in spring. Helicopters are liable to be out of radio contact at a range of 1-2 n mi.
	(b)	Outbound vessels should depart without delay if a Scirocco event is forecast. * Scirocco conditions may result in extremely anomalous radar and radio propagation due to the strong surface inversion over the water, especially during spring. Helicopters are liable to be out of radio contact at a range of 1-2 n mi.
(4) Small boats. Usually not authorized.	(a)	Small boat operations in the inner harbor should be unaffected. * Boat runs outside the harbor should be curtailed until conditions abate.
(1) Moored or Anchored - Inner harbor.	(a)	Little effect on ships moored alongside quays, anchored ships should move to a berth at a quay, or depart the harbor. * Mooring lines should be doubled if strong winds are forecast.
(2) Anchored - Paradiso Roads	(a)	Little effect on ships in the anchorage. * High terrain NW of the anchorage affords limited protection. * Ships should be alert for anchor dragging toward deeper water SE of the anchorage.
(3) Arriving/departing.	(a)	The high terrain NW of the Port and anchorage minimizes the effects of the wind. * Inbound vessels using berths in the harbor should double mooring lines if strong winds are forecast. * Vessels inbound for the Paradiso Roads anchorage should be alert for anchor dragging toward deeper water SE of the anchorage.
(4) Small boats. Usually not authorized.	(a)	Small boat operation should not be adversely affected as long as the boats stay close to the shore, where wave motion would be minimal.
All locations/situations.	(a)	Fine, gritty particles of ash can damage delicate equipment with close tolerances. * Secure unnecessary equipment. * Protect all equipment from contact with ash particles. * Change/clean air filters often on gasoline/diesel engines which must remain operating.
	(b)	Ash may pose health hazard. * Minimize personnel exposure on weather decks to avoid ash inhalation and exposure to accidents on slippery surfaces.
	(c)	In a powerfull eruption,visibility can be severely reduced.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November through February):

* Southeasterly winds: Called Scirocco, the wind creates the worst conditions at Messina. Wind speed will reach 45 kt in a strong outbreak, and be accompanied by 10 ft (3 m) waves in the strait. Stronger outbreaks are rare, but 70 kt is possible; if the outbreak coincides with a strong south-setting current, waves may reach 20 ft (6 m). Scirocco winds usually last about 3 days. A Scirocco normally brings hot, muggy weather in spring and summer, warm weather in winter. Scirocco winds are usually preceded by low clouds over the mainland to the southeast about 12 to 24 hr prior to onset. It is usually calm, with cloudless skies overhead, the day before a Scirocco begins. Cumuliform clouds which form and stay over Mt. Etna during periods of southeasterly flow over eastern Sicily are an indicator of a forthcoming Scirocco. It has been noted that when strong Scirocco winds cross Sicily, ships experience better weather conditions south of Sicily than north of the island, but sea conditions would be better on the north side. During a Scirocco, dense belts of altocumulus castellanus clouds approaching from the southwest are, at times, associated with radical and sudden changes in both direction and speed of the wind.
* Northwesterly Mistral winds to 45 kt reach the Messina area but the harbor and anchorage are protected by the high terrain.
* A "hat" cloud atop Mt. Etna usually means rain the next day. A larger cloud indicates more rain than a smaller one.

SPRING (March through May):

* Early spring conditions are much the same as winter. Most bad weather at Messina is over by the end of May.
* Early morning visibility is infrequently (1 or 2 times per season) reduced to near zero in fog.

SUMMER (June through September):

* Summer weather is generally good; Scirocco events are uncommon.

AUTUMN (October):

* Short transition season with winter-like weather returning by the end of the month.

NOTE: For more detailed information on hazardous weather conditions, see previous Table 2-1 in this section and Hazardous Weather Summary in Section 3.

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Brody, L. R. and M. J. R. Nestor, 1980: Regional Forecasting Aids for the Mediterranean Basin, NAVENVPREDRSCHFAC Technical Report TR80-10. Naval Environmental Prediction Research Facility, Monterey, CA 93941.

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Hydrographic Department, 1963: Mediterranean Pilot. Volume I. Hydrographer of the Navy, London, England.

Meteorological Officer, Air Ministry, 1962: Weather in the Mediterranean. Volume I, General Meteorology. Met. o. 391. Her Majesty's Stationery Office, London, England.

PORT VISIT INFORMATION

MAY 1988. NEPRF Meteorologists R. Fett and D. Perryman met with Chief Pilot Giuseppe Floridia and Pilot Salvatore Cutugno to obtain much of the information included in this port evaluation.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and Table 3-1 provides a summary of vessel locations/situations, potential hazards, effects, precautionary/evasive actions, and advance indicators and other information by season.

3.1 Geographic Location

The Port of Messina is located on the east coast of the Italian island of Sicily at approximately 38°12'N 15°34'E (Figure 3-1).

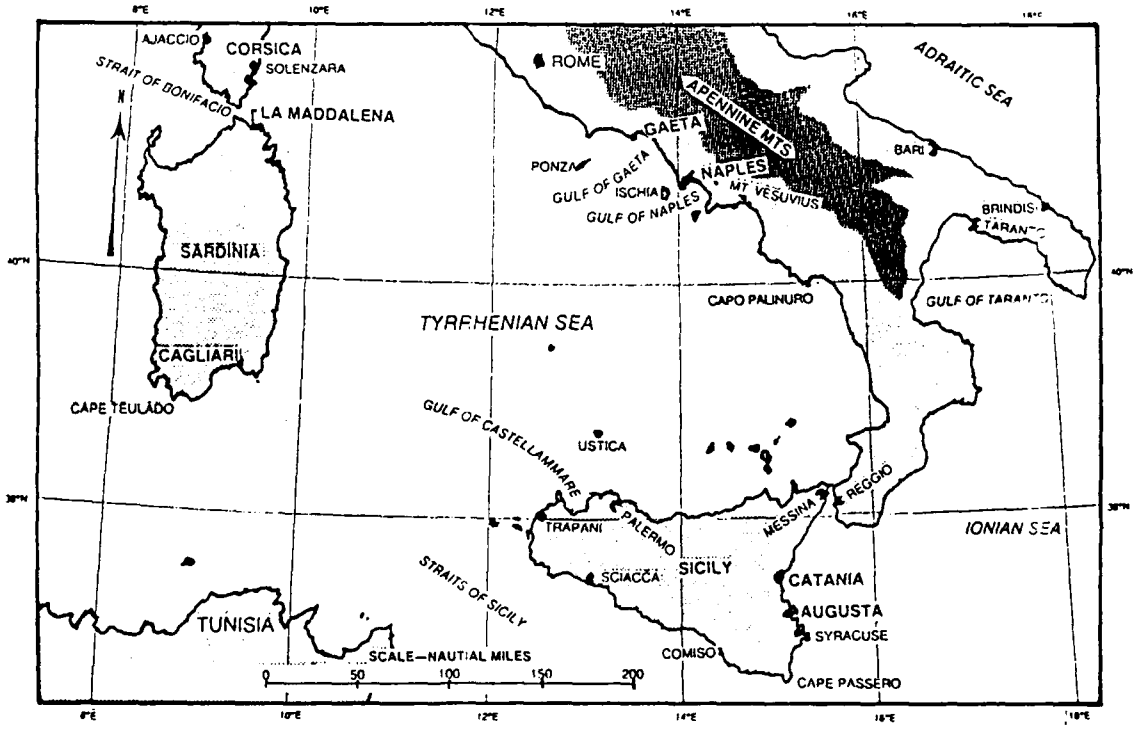

Figure 3-1. Central Mediterranean Sea.

The Port is located about 6 n mi southwest of the extreme northeastern tip of Sicily, on the Strait of Messina, a narrow passage which separates Sicily from the Italian Peninsula. See Figure 3-2. The terrain west and north of the Port is rugged, with elevations commonly exceeding 1,300 ft (396 m) within 2 miles of the coast. Mt. Etna, a 10,902 ft (3,323 m) active volcano, lies about 38 n mi southwest of the Port.

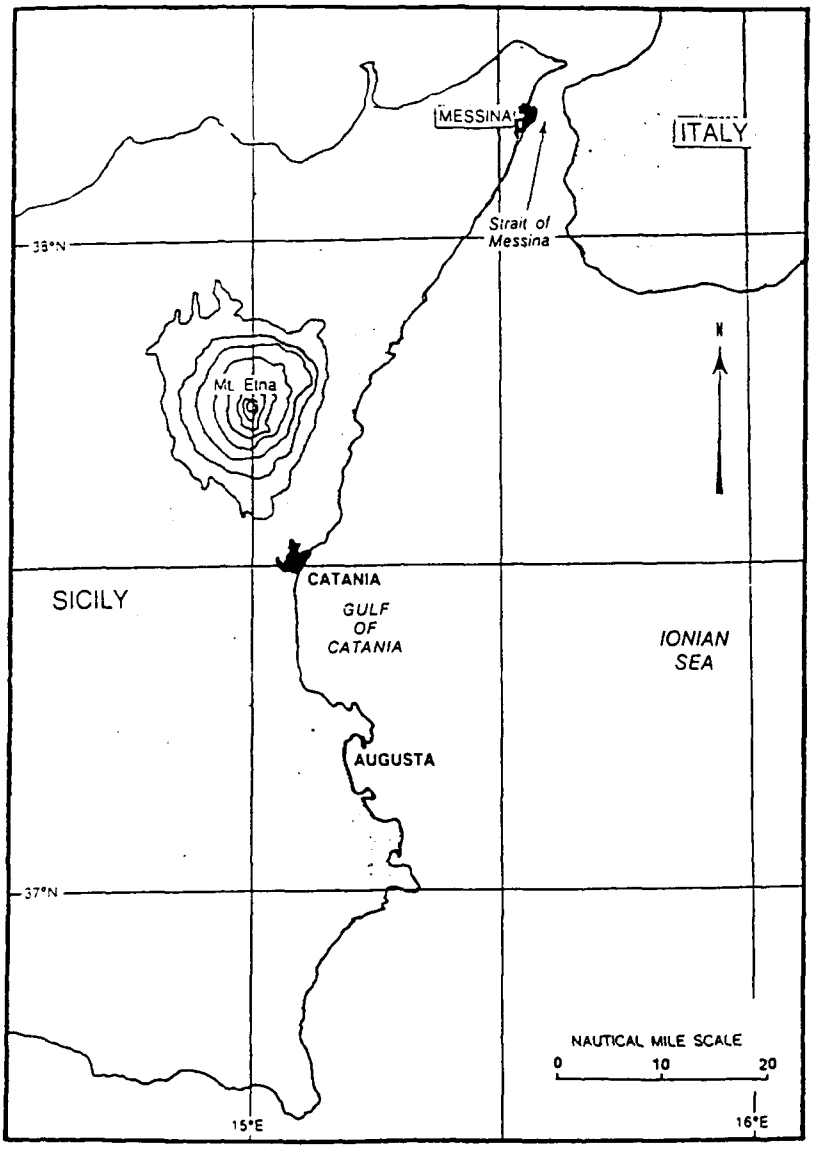

Figure 3-2. Eastern Sicily.

The Port of Messina is entered through a 1,350 ft (412 m) wide opening between Punta San Salvatore on the east and the east coast of Sicily on the west. The harbor is formed by an encircling peninsula, Braccio di San Raineri, which extends eastward from the main island, then turns northward and westward before terminating in Punta San Salvatore (Figure 3-3).

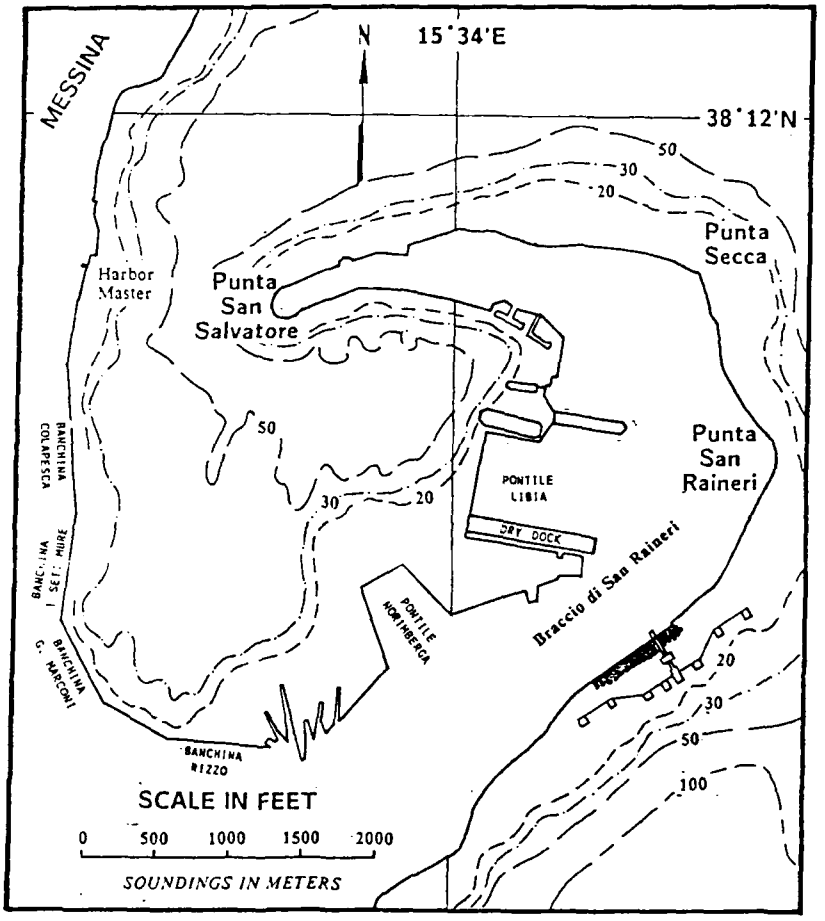

Figure 3-3. Port of Messina.

The harbor is not large, but is capable of accommodating vessels up to 820 ft (250 m) long with drafts to 29 ft (8.8 m). There is ample room for 2 LST's and an LPD at the downtown quaywall (FICEURLANT, 1986). Most berths used by U. S. Navy ships are at Banchina Colapesca and Banchina 1 Settembre, but berths at the dry docks on the harbor's east side are also used. Depths at quayside are in the 25 to 30 ft (7.6 to 9.1 m) range. In general, docking facilities are excellent for destroyer-type ships (FICEURLANT, 1986).

Anchorage is at Paradiso Roads, approximately 1.5 n mi north of the harbor entrance (Figure 3-3). Paradiso Roads offers good holding in 100 ft (30 m) depths with a sand and rock bottom. Because of strong, changeable currents at the anchorage, a 1/2 n mi swing radius is used. Ships may anchor in Messina harbor, but must be secured bow and stern to prevent swinging. Because of the abundant berthing space, U. S. Navy ships normally only anchor for a short time or not at all. Anchorage in the immediate vicinity outside the harbor is not recommended as the current is strong and the holding ground is poor.

Small boat operations are usually not authorized by the Port Captain because berths are normally available immediately or within a short period after arrival. When boating is authorized, an officer's landing is established at the Harbor Master's office, and the fleet landing is established on Banchina 1 Settembre.

3.2 Qualitative Evaluation of the Port of Messina

The inner harbor of the Port of Messina offers excellent protection from heavy weather. Vessels moored therein are exposed to winds emanating from north

clockwise through south, but careful precautionary safeguards (i.e. doubling of mooring lines) prior to wind onset will minimize any potential threat. The harbor is protected from hazardous waves.

The anchorage at Paridiso Roads is exposed and vulnerable to winds and waves clockwise from north to northeast and southeast to south and to the strong variable currents which are common to the Strait of Messina. A strong outbreak of southeasterly winds will make the anchorage too hazardous to use.

3.3 Currents and Tides

A strong tidal current exists in the Strait of Messina. This current is caused by the difference in tide heights in the Tyrrhenian Sea to the north and the Ionian Sea to the south. This tidal current will normally change directions about every six hours and is strongest in the narrowest and shallowest area of the strait. A strong northerly wind can reduce the duration of the north-setting current duration to 3 hours, and increase the south-setting current duration to 9.5 hours (Hydrographic Department, 1963). The south-setting current is the strongest of the two, with a speed of 3 to 4 kt commonly occurring. Maximum speed is 5 kt. The northerly setting current has a speed of 2 to 3 kt. According to local mariners, current speeds and the direction shift are more pronounced during full-moon periods, and during summer more than winter. Adjacent to Punta Secca and Punta San Raineri the current in the central part of the strait converges with a deflected, coastal current causing a swirling current which local mariners avoid as a matter of habit. Other eddies are formed along the strait between near shore counter-currents and the main current. The are locally called 'Bastardi' or 'Refloi' (mongrel) and extend about one-half n mi or less offshore. They begin 1 to 2 hours after the current changes directions. Small whirlpools (vortici) are seen in most parts of the strait especially after the tidal current has changed directions. Any one of them does not exist continuously but lasts up to about half an hour when it dies away and a new one starts up nearby. The whirlpools are not as strong today as they were in ancient times due to an earthquake in 1783 that altered the local topography. Even so, small craft should avoid these whirlpools when possible (Hydrographic Department, 1963). Tide rise and fall is minimal with a range of only 1.5 ft (.5 m) (FICEURLANT, 1986).

3.4 Visibility

Visibility is generally good at Messina, dropping below 2 n mi only 15 days during an average year. Visibility reduces to near zero in early morning fog 1 or 2 times per year, usually during spring. Mt. Etna, according to local authorities, is continually spewing small amounts of ash and will periodically emit larger amounts which can reduce visibility. In a powerful eruption, visibility can be reduced severely.

3.5 Hazardous Conditions

The Port of Messina is well protected from the effects of most hazardous weather scenarios. The unique shape of the encircling peninsula, Braccio de San Raineri, affords good protection from damaging wave action, but provides little protection from wind.

Although rare, storms having tropical cyclone characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean Basin. During the last occurrence, in September 1983, the storm moved from the Gulf of Gabes, through the Straits of Sicily, along the east coast of Sardina and into the Gulf of Genoa. Winds of 60 kt were reported at Cagliari, Sardina while winds near the storm's eye were 100 kt.

More commonly, cyclonic storms developing in the Gulf of Genoa and moving southeastward through the Tyrrhenian Sea and over Sicily or over southern Italy will cause most of Sicily's high winds. Depending on the location of the low, winds with a north or south component will have higher speeds in the area of the Strait of Messina due to funneling. These funneled winds can be as much as three times the speed of the synoptic wind.

A seasonal summary of various known environmental hazards that may be encountered in the Port of Messina follows.

A. Winter (November through February

The worst weather conditions at Messina are caused by southeasterly winds known as Sciroccos. A strong outbreak will usually bring 45 kt winds, and be accompanied by 10 ft (3 m) waves in the adjacent waters of the Strait of Messina. Extreme Scirocco events are rare, but bring winds of 70 kt and waves of almost 20 ft (6 m). The largest waves occur when the current is strong from the north. The opposing forces of the southeasterly wind and the southerly set of the current generate the larger waves. Scirocco events may occur during any month of the season, and usually last about 3 days. Sciroccos are normally caused by a well developed low pressure system over North Africa or winds within the warm sector of a low pressure system north of the Mediterranean Sea. A Scirocco will bring hot, muggy weather to the region in spring and summer, and warm weather in winter.

North and northeast winds which funnel through the Strait of Messina to the Port area cause a swell to occur in the harbor (FICEURLANT, 1986). These winds, which are most common in autumn, winter, and spring, are usually accompanied by good weather.

Northwesterly Mistral winds occasionally reach eastern Sicily from the Gulf of Lion. Although they may be as strong as 45 kt, they have little effect because of the protection afforded the harbor and anchorage by the high terrain. Mistral winds are strongest and most frequent late in the season, and in early spring.

January temperatures generally range from a mean low temperature of 47°F (8°C) to a mean high of about 57°F (14°C). Precipitation is at its yearly maximum in November, with an average accumulation of about 4.8 inches, and gradually decreases through the season to 3.6 inches in February (Meteorological Office, Air Ministry, 1962). Snowfall is rare and of little significance. Thunderstorms occur on an average of 3 days each November, decreasing to only 1 day in January and February.

B. Spring (March through May)

Early spring weather at Messina is similar to that of winter. Most of the strong Scirocco outbreaks are over by mid-May. Northwesterly Mistral winds occur early in the season, and are uncommon after April.

Early morning visibility is infrequently reduced to near zero on 1 or 2 days each spring season. Precipitation amounts decrease through the season, from a monthly average of 3.2 inches in March to 1.6 inches in May. Thunderstorms occur on an average of 2 days each March, but the probability decreases significantly in April and May.

C. Summer (June through September)

Although possible, Scirocco events are uncommon during summer. Also, strong winds from the northern quadrant no longer pose a threat to the region because of the northward displacement of the extratropical storm track. Afternoon sea breezes are insignificant at Messina.

August temperatures are the warmest of the year, with a mean maximum of 87°F (31°C) and a mean minimum of 72°F (22°C). Precipitation is at its yearly minimum in July, with an average accumulation of only 0.4 inches, but the amount increases to 2.3 inches during September. The possibility of thunderstorms also increases during September, occurring on an average of 2 days during the month.

D. Autumn (October)

The autumn season over eastern Sicily is short, normally lasting the month of October. The transition to winter-type weather occurs rapidly, as the extra-tropical storm track moves southward. Scirocco events occur with increasing frequency as winter approaches, as does the incidence of stronger north and northeasterly winds.

Precipitation amounts increase sharply in October, with an average of 4.7 inches being accumulated, more than doubling the total for September. Thunderstorms occur on an average of 2 days each October.

3.6 Harbor Protection

As detailed below, the inner harbor at the Port of Messina offers good protection from various hazards, while the anchorage at Paradiso Roads is largely exposed and vulnerable to winds and waves.

3.6.1 Wind and Weather

The Port of Messina is exposed to winds from north and northeast, and from southeast and south. East

winds are only rarely observed, and southwest clockwise through northwest winds are impeded by the terrain of Sicily.

Vessels moored in the inner harbor should experience few wind related problems if adequate precautions, such as doubling of mooring lines, are taken prior to wind onset. But vessels temporarily anchored in the inner harbor are at risk and should take immediate steps to move to a moorage along one of the quays or put to sea if strong winds are expected. Vessels in the anchorage at Paradiso Roads are at risk during strong winds from north to northeast and southeast to south, and should leave the anchorage for waters offering better protection, such as those south of Sicily or the Italian Peninsula during northerly winds, and north of Sicily during southerly winds. Northwest winds should pose no problems for ships in the anchorage due to the protection of the high terrain.

3.6.2 Waves

Vessels moored in the inner harbor should experience no problems from waves. North and northeasterly winds cause a swell in the harbor (FICEURLANT, 1986), but the effect on moored vessels is likely to be small.

Ships in the anchorage at Paradiso Roads are exposed to the full effect of waves raised by winds clockwise from north to northeast, and southeast to south. Consequently, ships should weigh anchor and seek waters offering better protection if strong winds/waves from those directions are forecast. Northwesterly Mistral winds do not have enough fetch length to raise problem waves at the anchorage.

3.7 Protective and Mitigating Measures

3.7.1 Sortie/Remain in Port

Ships moored to one of the quays in the harbor should find no need to sortie if strong winds are forecast, but mooring lines should be doubled and checked.

Vessels at temporary anchorage in the inner harbor should take immediate steps to move to an alongside berth at one of the quays, or weigh anchor and put to sea if strong winds are forecast.

3.7.2 Moving to a New Anchorage

If strong winds from north to northeast or southeast to south are forecast, ships in the anchorage at Paradiso Roads should weigh anchor and seek waters with better protection. When strong Scirocco (southerly) winds are forecast, moving north through the Strait of Messina to the north side of Sicily will afford calmer waters in the lee of the high terrain. Weather, however, may be worse. See Section 3.8 below.

3.7.3 Scheduling

The highest waves caused by Scirocco winds occur when the current has a south set through the Strait of Messina. Because the current changes direction every 6 hours (see Section 3.3 above), ship captains can take advantage of reduced wave heights if passage through the strait coincides with a current which has a north set. Waiting for the shift will result in diminished waves but not the winds.

3.8 Local Indicators of Hazardous Weather Conditions

Southeasterly Scirocco Winds - A Scirocco event is usually preceded by low clouds developing over the mainland to the southeast, about 12 to 24 hours prior to onset. It is usually calm, with cloudless skies overhead, the day before a Scirocco occurs.

Cumuliform clouds which form and stay over Mt. Etna during periods of southeasterly flow over eastern Sicily are an indicator of a forthcoming Scirocco. Increasing southerly winds at coastal stations along the northeast coast of Libya indicate the start of a Scirocco (Brody and Nestor, 1980).

Forecast a strong Scirocco if the following two conditions are met: (1) an upper trough is present over the Balkans with a strong jet stream along its southern boundary; and (2) large pressure falls (after the diurnal pressure change is removed) are observed at stations along the east coast of Tunisia (Brody and Nestor, 1980).

Scirocco conditions crossing the Island of Sicily produce strong and gusty foehn-type winds on the north and east sides of the island. It has been noted that during these situations, ships experience better weather conditions south of Sicily than north of the island. Sea conditions, however, would be better north of Sicily due to the short fetch (Brody and Nestor, 1980).

During a Scirocco, dense belts of altocumulus castellanus approaching from the southwest (probably associated with weak upper-level troughs) are, at times, associated with radical and sudden changes in both the direction and speed of the wind (Brody and Nestor, 1980).

The surface inversion that occurs over the relatively cool water during a spring Scirocco causes extremely anomalous radar and radio propagation in the dust-laden atmosphere below the inversion; helicopters are liable to be out of radio contact at a range of 1-2 n mi (Brody and Nestor, 1980). Low level slant visibility will be significantly reduced.

Weather associated with a Scirocco is largely dependent on both the length of the wind's overwater trajectory and the wind speed. High wind speeds and short overwater trajectories bring large amounts of dust that reduce visibilities, while low wind speeds and long overwater trajectories produce high humidities with fog and poor visibilities (Brody and Nestor, 1980).

Rain - A "hat" cloud atop Mt. Etna usually means rain the next day. Precipitation amounts are indicated by the cloud size; a larger cloud means more rain.

Northwesterly Mistral Winds - Wave clouds visible on satellite imagery extending from Sardinia to Sicily are indicative of a gale force Mistral that extends SE into the Strait of Sicily. Consequently, they could also indicate possible forthcoming northwesterly Mistral winds at Messina.

3.9 Summary of Problems, Actions, and Indicators

Table 3-1 is intended to provide easy-to-use seasonal references for meteorologists on ships using the Port of Messina. Table 2-1 (Section 2) summarizes Table 3-1 and is intended primarily for use by ship captains.

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Table 3-1. Potential problem situations at Port of Messin

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTI
1. Moored - inner harbor. OR Anchored - inner harbor. Occurs year-round less common in summer	a. SE'ly winds/waves - Called Scirocco. Strong outbreak may reach 45 kt, but associated waves to 10 ft (3 m) would not reach the inner harbor. Rare stronger outbreaks may bring 70 kt winds. Waves to 20 ft (6 m) may occur in Strait of Messina when stronger winds coincide with a south-setting current. Scirocco events are most common between October and mid-May and normally last about 3 days. Sciroccos usually bring hot, muggy weather in spring and summer, warm weather in winter.	a. The inner harbor is well protected, ships should remain at double lines. Vessels anchored in inner harbor should move to depart harbor. Sortie to the N through Strait of Messina and w protected waters N of Sicily. Scirocco winds crossing Sicily p strong and gusty foehn-type winds on the N and E sides of the i Experience shows better weather conditions S of Sicily than N d Scirocco. Sea conditions, however, would be better N of Sicily the short fetch. The surface inversion that occurs over the re cool water during a spring Scirocco causes extremely anomalous radio propagation in the dust-laden atmosphere below the invers helicopters may be out of radio contact at a range of 1-2 n mi.
Most common late Winter and early Spring Uncommon in Summer May occur in Autumn	b. NW'ly winds - NW'ly Mistral winds spreading SE from the Gulf of Lion occasionally reach Messina. Although it may reach 45 kt, the wind has little adverse effect on the Port because of the protection afforded by the high terrain of E Sicily. Usually accompanied by good weather.	b. Minimal impact on berthed vessels. Doubling of mooring lin suffice in the unlikely event that strong winds reach the Port. small size of the harbor makes it advisable for ships at anchor harbor to move to a berth at one of the quays or weigh anchor a the harbor if a strong event is forecast.
Independent of season	c. Ash fall from Mr. Etna - Common occurrence anytime Mt. Etna erupts or emits an ash plume and the prevailing wind is from SW.	c. The ash is slippery and will clog machinery. Visibility is not severely affected but, in a powerfull eruption, can be near Wherever possible, exposed machinery should be secured and prot ash. Personnel should take precautions against accidental slip ash covered decks, and avoid inhalation of the ash.
2. Anchored - Paradiso Roads. OR Arriving/departing. Occurs year-round less common in summer.	a. SE'ly winds/waves - Called Scirocco. Strong outbreak may reach 45 kt, with associated waves to 10 ft (3 m) reaching the area. Rare stronger outbreaks may bring 70 kt winds. Waves to 20 ft (6 m) may reach the area when the stronger winds coincide with a south-setting current. Outside the harbor entrance and in the Paradiso Roads anchorage area the full effects of the wind and waves are felt. The inner harbor is not significantly affected. Scirocco events are most common between October and mid-May and normally last about 3 days. Sciroccos usually bring hot, muggy weather in spring and summer, warm weather in winter.	a. The anchorage is fully exposed to winds and waves. Vessels sortie if strong winds are forecast. Waters offering more prot be found by moving N through the Strait of Messina, and then W of high terrain of N Sicily. Although vessels can enter the Po wind, inbound vessels should ensure that a quay berth is availa entering. Once alongside, double mooring lines should be used early to avoid the worst of the winds/waves outside the harbor. winds crossing Sicily produce strong and gusty foehn-type winds and E sides of the island. Experience shows better weather con of Sicily than N during Scirocco, but sea conditions are better Sicily. Surfaces inversion occur during spring Sciroccos causi extremely anomalous radar and radio propagation in the dust-lad atmosphere below the inversion; helicopters may be out of radi at a range of 1-2 n mi.
Most common late Winter and early Spring Uncommon in Summer May occur in Autumn	b. NW'ly winds - NW'ly Mistral winds spreading SE from the Gulf of Lion occasionally reach Messina. Although it may reach 45 kt, the wind has little adverse effect on the anchorage or Port because of the protection afforded by the high terrain of NE Sicily. Usually accompanied by good weather.	b. The protection afforded by the high terrain NW of the ancho Port minimizes the effects of the wind. Although holding is go sand and rock bottom, a careful watch is advised to detect anch dragging toward deeper water SE of the anchorage. Inbound vess berths in the harbor should use double mooring lines if strong forecast.
Independent of season	c. Ash fall from Mr. Etna - Common occurrence anytime Mt. Etna erupts or emits an ash plume and the prevailing wind is from SW.	c. The ash is slippery and will clog machinery. Visibility is not severely affected but, in a powerfull eruption, can be near Wherever possible, exposed machinery should be secured and prot ash. Personnel should take precautions against accidental slip ash covered decks, and avoid inhalation of the ash.

1 OF 2

ituations at Port of Messina, Sicily, Italy - ALL SEASONS

PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
r is well protected, ships should remain at berths and els anchored in inner harbor should move to berths or tie to the N through Strait of Messina and westward to of Sicily. Scirocco winds crossing Sicily produce ehn-type winds on the N and E sides of the island. tter weather conditions S of Sicily than N during itions, however, would be better N of Sicily due to ne surface inversion that occurs over the relatively spring Scirocco causes extremely anomalous radar and n the dust-laden atmosphere below the inversion; out of radio contact at a range of 1-2 n mi.	a. Scirocco winds are usually associated with a well-developed low pressure system over N Africa or the warm sector of a low pressure system located N of the Mediterranean Sea. Indicators include low clouds over the mainland to the SE which precede onset by 12-24 and cumuliform clouds which form and stay over Mt. Etna. It is usually calm, with cloudless skies overhead, the day before a Scirocco occurs. Increasing S'ly winds at Libya coastal stations indicate the start of a Scirocco. Forecast a strong Scirocco when: (1) an upper trough is present over the Balkans with a strong jet stream along its S boundary; and (2) large pressure falls (after the diurnal pressure change is removed) at stations along the E coast of Tunisia. Weather is largely dependent on the length of the wind's overwater trajectory and the wind speed. High wind speeds and short overwater trajectories produce large amounts of dust that reduce visibilities, while low wind speeds and long overwater trajectories produce high humidities with fog and poor visibilities. Dense belts of altocumulus castellanus approaching from SW, are at times associated with radical and sudden changes in both the direction and speed of the wind.
on berthed vessels. Doubling of mooring lines should ikely event that strong winds reach the Port. The harbor makes it advisable for ships at anchor in the berth at one of the quays or weigh anchor and depart ong event is forecast.	b. Mistral winds reaching Messina spread SE after initial onset in the Gulf of Lion. Wind reports over the W Mediterranean Basin should be monitored for signs of a significantly strong outbreak. Wave clouds visible on satellite imagery extending from Sardinia to Sicily are indicative of a gale force Mistral that extends SE into the Strait of Sicily. Consequently, they could also indicate possible forthcoming NW Mistral winds at Messina.
ppery and will clog machinery. Visibility is usually ed but, in a powerfull eruption, can be near zero. exposed machinery should be secured and protected from uld take precautions against accidental slipping on and avoid inhalation of the ash.	c. Ash falls are possible whenever Mt. Etna erupts or emits an ash plume and prevailing winds are from SW.
s fully exposed to winds and waves. Vessels should nds are forecast. Waters offering more protection can N through the Strait of Messina, and then W to the lee N Sicily. Although vessels can enter the Port in any els should ensure that a quay berth is available before ngside, double mooring lines should be used. Sortie worst of the winds/waves outside the harbor. Scirocco ly produce strong and gusty foehn-type winds on the N island. Experience shows better weather conditions S uring Scirocco, but sea conditions are better N of nversion occur during spring Sciroccos causing radar and radio propagation in the dust-laden e inversion; helicopters may be out of radio contact mi.	a. Scirocco winds are usually associated with a well-developed low pressure system over N Africa or the warm sector of a low pressure system located N of the Mediterranean Sea. Indicators include low clouds over the mainland to the SE which precede onset by 12-24 and cumuliform clouds which form and stay over Mt. Etna. It is usually calm, with cloudless skies overhead, the day before a Scirocco occurs. Increasing S'ly winds at Libya coastal stations indicate the start of a Scirocco. Forecast a strong Scirocco when: (1) an upper trough is present over the Balkans with a strong jet stream along its S boundary; and (2) large pressure falls (after the diurnal pressure change is removed) at stations along the E coast of Tunisia. Weather is largely dependent on the length of the wind's overwater trajectory and the wind speed. High wind speeds and short overwater trajectories produce large amounts of dust that reduce visibilities, while low wind speeds and long overwater trajectories produce high humidities with fog and poor visibilities. Dense belts of altocumulus castellanus approaching from SW, are at times associated with radical and sudden changes in both the direction and speed of the wind.
afforded by the high terrain NW of the anchorage and effects of the wind. Although holding is good on a m, a careful watch is advised to detect anchor per water SE of the anchorage. Inbound vessels using or should use double mooring lines if strong winds are	b. Mistral winds reaching Messina spread SE after initial onset in the Gulf of Lion. Wind reports over the W Mediterranean Basin should be monitored for signs of a significantly strong outbreak. Wave clouds visible on satellite imagery extending from Sardinia to Sicily are indicative of a gale force Mistral that extends SE into the Strait of Sicily. Consequently, they could also indicate possible forthcoming NW Mistral winds at Messina.
ppery and will clog machinery. Visibility is usually ed but, in a powerfull eruption, can be near zero. exposed machinery should be secured and protected from uld take precautions against accidental slipping on and avoid inhalation of the ash.	c. Ash falls are possible whenever Mt. Etna erupts or emits an ash plume and prevailing winds are from SW.

Table 3-1. (Contin

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVAS
3. Small boats. Usually not authorized by Port Captain. Occurs year-round less common in summer.	a. SE'ly winds/waves - Called Scirocco. A strong outbreak may reach 45 kt with waves to 10 ft (3 m). Rare stronger outbreaks may bring 70 kt winds. Waves to 20 ft (6 m) may result when strongest winds coincide with a south-setting current through the strait. The inner harbor is not significantly affected but the anchorage at Paradiso Roads would feel the full effects of wind and waves. Scirocco events are most common between October and mid-May and normally last about 3 days. Sciroccos usually bring hot, muggy weather in spring and summer, warm weather in winter.	a. Boating should not be seriously affected within harbor, but runs to/from the harbor and the anchora would be hazardous and should be curtailed until wi
Most common late Winter and early Spring Uncommon in Summer May occur in Autumn	b. NW'ly winds - NW'ly Mistral winds spreading SE from the Gulf of Lion occasionally reach Messina. Although they may reach 45 kt, they have little effect on the Port or anchorage at Paradiso Roads due to the protection afforded by the high terrain of NE Sicily. Usually accompanied by good weather.	b. Boating should be largely unaffected unless boa protection of the lee coastline.
Independent of season	c. Ash fall from Mr. Etna - Common occurrence anytime Mt. Etna erupts or emits an ash plume and the prevailing wind is from SW.	c. Safe boating operations during an ash fall wou the ash fall itself; it would be dependent on wind SW'ly flow would necessarily predominate from the ft in order for the ash to reach the Port, so it w such an offshore flow would cause significant prob Of greater concern would be the threat of ash cont engines. Curtailment of small boat operations wou ash fall ends. If operations are impossible to cu filtration of the air supply to the engines should should be changed or cleaned often. Personnel sho against accidental slipping on accommodation ladde In a powerful eruption, visibility may be reduced

1 OF 2

Table 3-1. (Continued)

— PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
ld not be seriously affected within the confines of the to/from the harbor and the anchorage at Paradiso Roads us and should be curtailed until winds/waves abate.	a. Scirocco winds are usually associated with a well-developed low pressure system over N Africa or the warm sector of a low pressure system located N of the Mediterranean Sea. Indicators include low clouds over the mainland to the SE which precede onset by 12-24 and cumuliform clouds which form and stay over Mt. Etna. It is usually calm, with cloudless skies overhead, the day before a Scirocco occurs. Increasing S'ly winds at Libya coastal stations indicate the start of a Scirocco. Forecast a strong Scirocco when: (1) an upper trough is present over the Balkans with a strong jet stream along its S boundary; and (2) large pressure falls (after the diurnal pressure change is removed) at stations along the E coast of Tunisia. Weather is largely dependent on the length of the wind's overwater trajectory and the wind speed. High wind speeds and short overwater trajectories produce large amounts of dust that reduce visibilities, while low wind speeds and long overwater trajectories produce high humidities with fog and poor visibilities. Dense belts of altocumulus castellanus approaching from SW, are at times associated with radical and sudden changes in both the direction and speed of the wind.
ld be largely unaffected unless boats move away from the e lee coastline.	b. Mistral winds affecting Messina spread SE after initial onset in the Gulf of Lion. Wind reports over the W Mediterranean Basin should be monitored for signs of a significantly strong outbreak. Wave clouds visible on satellite imagery extending from Sardinia to Sicily are indicative of a gale force Mistral that extends SE into the Strait of Sicily. Consequently, they could also indicate possible forthcoming NW Mistral winds at Messina.
operations during an ash fall would be independent of elf; it would be dependent on wind and wave conditions. necessarily predominate from the surface to above 10,000 the ash to reach the Port, so it would be unlikely that flow would cause significant problems for small boats. rn would be the threat of ash contamination of the boat lment of small boat operations would be prudent until the If operations are impossible to curtail, additional e air supply to the engines should be used. Air filters d or cleaned often. Personnel should take precautions al slipping on accommodation ladders and other surfaces. uption, visibility may be reduced to near zero.	c. Ash falls are possible whenever Mt. Etna erupts or emits an ash plume and prevailing winds are from SW.

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PORT VISIT INFORMATION

MAY 1988. NEPRF Meteorologists R. Fett and D. Perryman met with Chief Pilot Giuseppe Floridia and Pilot Salvatore Cutugno to obtain much of the information included in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides some general definitions regarding waves and is extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955).

Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN- BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period ($f = 1/T$) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A Beaufort Scale table with related wave effects is shown on the following page.

BEAUFORT SCALE

Beaufort Number	Wind Speed Knots	Wind Speed MPH	Seaman's term	Effects observed at sea	Term and height of Waves in meters
0	Under 1	Under 1	Calm	Sea like mirror.	Calm, glassy, 0
1	1-3	1-3	Light air	Ripples with appearance of scales; no foam crests.	
2	4-6	4-7	Light breeze	Small wavelets; crests of glassy appearance, not breaking	Rippled, less than 0.5
3	7-10	8-12	Gentle breeze	Large wavelets; crests begin to break; scattered whitecaps.	Smooth, 0.5
4	11-16	13-18	Moderate breeze	Small waves, becoming longer; numerous whitecaps.	Slight, 1.0
5	17-21	19-24	Fresh breeze	Moderate waves, taking longer form; many whitecaps; some spray.	Moderate, 1.0-2.5
6	22-27	25-31	Strong breeze	Larger waves forming; whitecaps everywhere; more spray.	Rough, 2.5-4.0
7	28-33	32-38	Moderate gale	Sea heaps up; white foam from breaking waves begins to be blown up in streaks.	
8	34-40	39-46	Fresh gale	Moderate high waves; edges of crests begin to break; foam is blown in steaks.	Very rough, 4.0-6.0
9	41-47	47-54	Strong gale	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.	
10	48-55	55-63	Whole gale	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.	High, 6.0-9.0
11	56-63	64-72	Storm	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.	Very high, 9.0-13.5
12 13 14 15 16 17	64-71 72-80 81-89 90-99 100-108 109-118	73-82 83-92 93-103 104-114 115-125 126-136	Hurricane	Air filled with foam; sea completely white with driving spray; visibility greatly reduced. Winds of force 12 and above very rarely experienced on land; usually accompanied by widespread damage.	Phenomenal, greater than 13.5

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24E	Mine Warfare Command
24G1	Submarine Force Commander LANT
26QQ1	Special Warfare Group LANT
28A1	Carrier Group LANT (2)
28B1	Cruiser-Destroyer Group LANT (2)
28D1	Destroyer Squadron LANT (2)
28J1	Service Group and Squadron LANT (2)
28K1	Submarine Group and Squadron LANT
28L1	Amphibious Squadron LANT (2)
29A1	Guided Missile Cruiser LANT
29B1	Aircraft Carrier LANT
29D1	Destroyer LANT (DO 931/945 Class)
29E1	Destroyer LANT (DO 963 Class)
29F1	Guided Missile Destroyer LANT
29G1	Guided Missile Frigate (LANT)
29I1	Frigate LANT (FF 1098)
29J1	Frigate LANT (FF 1040/1051 Class)
29K1	Frigate LANT (FF 1052/1077 Class)
29L1	Frigate LANT (FF 1078/1097 Class)
29N1	Submarine LANT #SSN}
29Q	Submarine LANT SSBN
29R1	Battleship Lant (2)
29AA1	Guided Missile Frigate LANT (FFG 7)
29BB1	Guided Missile Destroyer (DDG 993)
31A1	Amphibious Command Ship LANT (2)
31B1	Amphibious Cargo Ship LANT
31G1	Amphibious Transport Ship LANT
31H1	Amphibious Assault Ship LANT (2)
31I1	Dock Landing Ship LANT
31J1	Dock Landing Ship LANT
31M1	Tank Landing Ship LANT
32A1	Destroyer Tender LANT
32C1	Ammunition Ship LANT
32G1	Combat Store Ship LANT
32H1	Fast Combat Support Ship LANT
32N1	Oiler LANT
32Q1	Replenishment Oiler LANT
32S1	Repair Ship LANT
32X1	Salvage Ship LANT

32DD1	Submarine Tender LANT
32EE1	Submarine Rescue Ship LANT
32KK	Miscellaneous Command Ship
32QQ1	Salvage and Rescue Ship LANT
32TT	Auxiliary Aircraft Landing Training Ship
42N1	Air Anti-Submarine Squadron VS LANT
42P1	Patrol Wing and Squadron LANT
42BB1	Helicopter Anti-Submarine Squadron HS LANT
42CC1	Helicopter Anti-Submarine Squadron Light HSL LANT
C40	Monterey, Naples, Sigonella and Souda Bay only
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FD4	Oceanography Center - NAVEASTOCEANCEN
FD5	Oceanography Command Center - COMNAVOCEANCOM (Rota)

copy to:

21A2	CINCPACFLT
22A2	Fleet Commander PAC
24F	Logistics Command
24H1	Fleet Training Command LANT
28A2	Carrier Group PAC (2)
29B2	Aircraft Carrier PAC (2)
29R2	Battleships PAC (2)
31A2	Amphibious Command Ship PAC (2)
31H2	Amphibious Assault Ship PAC (2)
FA2	Fleet Intelligence Center
FC14	Air Station NAVEUR
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